Claims

What is claimed is:

1. A method for providing representation of high quality, substantially visually error-free color in images, comprising the steps of:

mapping color to color data values in an expanded RGB/RGBA space; and

labeling an image determined by mapped color values as an expanded RGB/RGBA colorspace image.

2. The method of claim 1 wherein mapping includes, where colors from a selected colorspace are converted to the expanded RGB/RGBA colorspace, mapping color data values of a source colorspace image to color data values of the expanded RGB/RGBA colorspace.

3. The method of claim 1 wherein mapping includes, where colors in the expanded RGB/RGBA colorspace are converted to a selected colorspace, mapping color data values of the expanded RGB/RGBA colorspace to color data values of a destination colorspace.

4. The method of claim 3 wherein, where the color data values in the expanded RGB/RGBA colorspace lie outside a range of the destination colorspace, mapping includes clipping the color data values for the destination colorspace.

5. The method of claim 3 wherein, where the color data values in the expanded RGB/RGBA colorspace lie outside the range of the destination colorspace, mapping includes utilizing a

predetermined transformation function that maps the color data values to color data values in the selected destination colorspace.

6. The method of claim 1 wherein the expanded RGB/RGBA colorspace is linear in visual intensity.

7. The method of claim 1 wherein the expanded RGB/RGBA space is an XsRGB colorspace that includes at least the visible range of color values, and where selected, wherein the expanded RGB/RGBA space includes an alpha channel for at least one of: transparency information and opaqueness information.

8. The method of claim 1 wherein the expanded RGB/RGBA space includes a colorspace defined by a gamut that extends into negative component values and beyond 1.0 when normalized to 1.0 in RGB.

9. The method of claim 1 wherein mapping the color values to an expanded RGB/RGBA space includes utilizing multiplication of R_0, G_0, B_0 values by a predetermined matrix, where the R_0, G_0, and B_0 values denote normalized numerically linear red, green and blue components for a color value.

10. The method of claim 9 wherein the R_0, G_0, B_0 values are obtained in accordance with the following:

$$\begin{bmatrix} R_0 \\ G_0 \\ B_0 \end{bmatrix} = \begin{bmatrix} 3.241 & -1.5374 & -0.4986 \\ -0.9692 & 1.8760 & 0.0416 \\ 0.0556 & -0.2040 & 1.0570 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

wherein X, Y, and Z denote 1931 Commission Internationale de l'Eclairage XYZ values where Y has been normalized to 1.

11. The method of claim 1 wherein, wherein each color data value uses a signed 16 bit integer and 13 bits are used as a decimal portion.

12. The method of claim 11 wherein 16 bit components R_{16}, G_{16} and B_{16} are given by:

$$\begin{bmatrix} R_{16} \\ G_{16} \\ B_{16} \end{bmatrix} = 8192 \times \begin{bmatrix} R_0 \\ G_0 \\ B_0 \end{bmatrix}$$

where the $R_0, G_0,$ and B_0 values denote normalized numerically linear red, green and blue components for a color value.

13. The method of claim 4 wherein mapping includes, where color data values have been represented using signed 16 bit values with 13 bits of decimal precision, clipping the 16 bit values below 0 and above 8192 to convert the 16 bit values to 8 bit values.

14. The method of claim 1 wherein the color data values are one of:

non-premultiplied color data values;

premultiplied color data values; and

normalized numerically linear premultiplied color data values.

15. In a digitized image processing system in which an image digitizer outputs digital signals representing an image, a method for providing representation of high quality, substantially visually error-free color images from measured color values, comprising the steps of:

mapping the measured color values to an expanded colorspace wherein the expanded colorspace includes values beyond a visible range of color values; and

labeling an image determined by the color values mapped to the expanded colorspace as an expanded colorspace image.

16. The method of claim 15 wherein the expanded colorspace includes an XsRGB colorspace defined by a gamut that extends into negative component values and beyond 1.0 when normalized to 1.0 in RGB , and where selected, wherein the expanded RGB/RGBA space includes an alpha channel for at least one of: transparency information and opaqueness information

17. The method of claim 15 wherein mapping the color values to an expanded colorspace includes utilizing multiplication of R_0, G_0, B_0 values by a predetermined matrix, where the R_0, G_0, B_0 values denote normalized numerically linear red, green and blue components for a color value.

18. The method of claim 15 wherein the R_0, G_0, B_0 values are obtained in accordance with the following:

$$\begin{bmatrix} R_0 \\ G_0 \\ B_0 \end{bmatrix} = \begin{bmatrix} 3.241 & -1.5374 & -0.4986 \\ -0.9692 & 1.8760 & 0.0416 \\ 0.0556 & -0.2040 & 1.0570 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

wherein X, Y, and Z denote 1931 Commission Internationale de l'Eclairage XYZ values wherein Y has been normalized to 1.

19.The method of claim 15 wherein, wherein each color data value uses a 16 bit integer and 13 bits are used as a decimal portion.

20. The method of claim 15 wherein 16 bit components R_{16}, G_{16}, and B_{16} of color data values are given by:

$$\begin{bmatrix} R_{16} \\ G_{16} \\ B_{16} \end{bmatrix} = 8192 \times \begin{bmatrix} R_0 \\ G_0 \\ B_0 \end{bmatrix}$$

where the R_0, G_0, B_0 values denote normalized numerically linear red, green and blue components for a color value.

21. The method of claim 15 wherein mapping includes, where color data values have been represented using signed 16 bit values with 13 bits of decimal precision, clipping the 16 bit values below 0 and above 8192 to convert the 16 bit values to 8 bit values.

22. The method of claim 15 wherein the color data values are one of:

non-premultiplied color data values;

premultiplied color data values; and

normalized numerically linear premultiplied color data values.

23. A computer-readable medium having computer-executable instructions for performing the steps recited in claim 15.

24. In a digitized image processing system in which an image digitizer utilizes color image information to output digital signals representing a color image to an apparatus that uses the digital signals to provide representation of a high quality visually error-free expanded colorspace color image, the apparatus comprising:

an expanded colorspace mapper, for mapping the digital signals to expanded colorspace values wherein the expanded colorspace values include values beyond a visible range of color values; and

an image labeller, coupled to the expanded colorspace mapper, for labeling an image determined by expanded colorspace values as an expanded colorspace image.

25. The apparatus of claim 24 wherein the expanded colorspace includes an XsRGB colorspace defined by a gamut that extends into negative component values and beyond 1.0 when normalized to 1.0 in RGB, and where selected, wherein the expanded RGB/RGBA space includes an alpha channel for at least one of: transparency information and opaqueness information

26. The apparatus of claim 24 wherein the expanded colorspace mapper utilizes multiplication of R_0, G_0, B_0 values by a predetermined matrix to map the color values to an expanded colorspace.

27. The apparatus of claim 24 wherein the R_0, G_0, B_0 values are obtained in accordance with the following:

$$\begin{bmatrix} R_0 \\ G_0 \\ B_0 \end{bmatrix} = \begin{bmatrix} 3.241 & -1.5374 & -0.4986 \\ -0.9692 & 1.8760 & 0.0416 \\ 0.0556 & -0.2040 & 1.0570 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

wherein X, Y, and Z denote 1931 Commission Internationale de l'Eclairage XYZ values where Y has been normalized to 1.

28. The apparatus of claim 24 wherein, wherein each color data value uses a 16 bit integer and 13 bits are used as a decimal portion.

29. The apparatus of claim 24 wherein 16 bit components of color data values R_{16}, G_{16}, and B_{16} are given by:

$$\begin{bmatrix} R_{16} \\ G_{16} \\ B_{16} \end{bmatrix} = 8192 \times \begin{bmatrix} R_0 \\ G_0 \\ B_0 \end{bmatrix}$$

where the R_0, G_0, B_0 values denote normalized numerically linear red, green and blue components for a color value.

30. The apparatus of claim 24 wherein, where color data values have been represented using signed 16 bit values with 13 bits of decimal precision, the expanded colorspace mapper clips the 16 bit values below 0 and above 8192 to convert the 16 bit values to 8 bit values.

31. The apparatus of claim 24 wherein the color data values are one of:

non-premultiplied color data values;

premultiplied color data values; and

normalized numerically linear premultiplied color data values.

32. A computer-readable medium having computer-executable instructions for performing steps comprising:

mapping color values to an expanded RGB/RGBA space; and

labeling an image determined by mapped color values as an expanded RGB/RGBA colorspace image.

33. The computer-readable medium of claim 32 wherein the expanded RGB/RGBA space includes an XsRGB colorspace that includes at least the visible range of color values, and where selected, wherein the expanded RGB/RGBA space includes an alpha channel for at least one of: transparency information and opaqueness information.

34. The computer-readable medium of claim 32wherein the expanded RGB/RGBA space includes a colorspace defined by a gamut that extends into negative component values and beyond 1.0 when normalized to 1.0 in RGB.

35. The computer-readable medium of claim 32 wherein mapping the color values to an expanded RGB/RGBA space includes utilizing multiplication of R_0, G_0, B_0 values by a predetermined matrix.

36. The computer-readable medium of claim 32 wherein the R_0, G_0, B_0 values are obtained in accordance with the following:

$$\begin{bmatrix} R_0 \\ G_0 \\ B_0 \end{bmatrix} = \begin{bmatrix} 3.241 & -1.5374 & -0.4986 \\ -0.9692 & 1.8760 & 0.0416 \\ 0.0556 & -0.2040 & 1.0570 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

wherein X, Y, and Z denote 1931 Commission Internationale de l'Eclairage XYZ values where Y has been normalized to 1.

37. The computer-readable medium of claim 32 wherein each color data value uses a signed 16 bit integer and 13 bits are used as a decimal portion.

38. The computer-readable medium of claim 32 wherein 16 bit components R_{16}, G_{16}, and B_{16} are given by:

$$\begin{bmatrix} R_{16} \\ G_{16} \\ B_{16} \end{bmatrix} = 8192 \times \begin{bmatrix} R_0 \\ G_0 \\ B_0 \end{bmatrix}$$

where the R_0, G_0, B_0 values denote normalized numerically linear red, green and blue components for a color value.

39. The computer-readable medium of claim 32 wherein mapping includes, where color data values have been represented using signed 16 bit values with 13 bits of decimal precision, clipping the 16 bit values below 0 and above 8192 to convert the 16 bit values to 8 bit values.

40. The computer-readable medium of claim 32 wherein the color data values are one of:

non-premultiplied color data values;

premultiplied color data values; and

normalized numerically linear premultiplied color data values.

41. The computer-readable medium of claim 32 wherein the expanded RGB/RGBA space includes an alpha channel for at least one of: transparency information and opaqueness information.

42. A method of representation of color in images using color data values for an expanded RGB/RGBA space, having at least a precision and range sufficient to represent substantially all humanly visible colors substantially without visually perceptible error, the method including the steps of:

representing the color as data values in an expanded RGB/RGBA space; and

labeling an image determined by the color data values as an expanded RGB/RGBA colorspace image.

43. The method of claim 42 wherein representing includes, where color data values from a selected colorspace are converted to the expanded RGB/RGBA space, mapping the color data values of a selected image colorspace to color data values of the expanded RGB/RGBA colorspace.

44. The method of claim 42 wherein representing includes, where color data values in the expanded RGB/RGBA space are converted to a selected colorspace, mapping the color data values of the expanded RGB/RGBA colorspace to a selected destination colorspace.

45. The method of claim 44 wherein, where the perceptually visible data values lie outside a predetermined range, the mapping includes clipping the color data valuesto a range of the selected destination colorspace.

46. The method of claim 44 wherein the mapping includes utilizing a predetermined transformation function that maps the color data values to color data values in the selected destination colorspace.

47. The method of claim 42 wherein the expanded RGB/RGBA colorspace is linear in visual intensity.

48. A method for representing at least one of: super transparent and super opaque colors using an alpha channel, comprising the steps of:

representing color data values as perceptually visible super transparent/super opaque data values in a colorspace; and

labeling an image determined by the perceptually visible super transparent/super opaque data values as a super transparent/super opaque colorspace image.

49. The method of claim 1 wherein color operations defined in RGB/RGBA colorspace are extended to an expanded RGB/RGBA colorspace.

50. The method of claim 48 wherein the alpha channel extends less than 0 and beyond 1.0 when normalized to 1.0.

51. A method of representing color data values in images using color data as appearance RGB values, comprising the steps of:

representing the color data values as normalized RGB values wherein each normalized RGB value (R_w, G_w, B_w) is obtained using a predetermined transformation matrix that is based on a preselected spectrum distribution; and

labeling an image determined by the normalized RGB values as an appearance match image for corresponding *X, Y,* and *Z* values in accordance with 1931 Commission Internationale de l'Eclairage where Y has been normalized to 1.

52. A device for representing color data values in images using color data as appearance RGB values, comprising:

an expanded colorspace mapper, arranged to represent the color data values as normalized RGB values wherein each normalized RGB value (R_w, G_w, B_w) is obtained using a predetermined transformation matrix that is based on a preselected spectrum distribution; and

an image labeller, for labeling an image determined by the normalized RGB values as an appearance match image for corresponding *X, Y,* and *Z* values in accordance with 1931 Commission Internationale de l'Eclairage where Y has been normalized to 1.

53. A method of representing color data values in images using color data as absolute RGB values, comprising the steps of:

representing the color data values as absolute RGB values wherein each absolute RGB value (R_0, G_0, B_0) is obtained using a predetermined transformation matrix that is based on a standard 1931 Commission Internationale de l'Eclairage D65 spectrum distribution; and

labeling an image determined by the absolute RGB values as an absolute match image for corresponding *X, Y,* and *Z* values in accordance with 1931 Commission Internationale de l'Eclairage where Y has been normalized to 1.

54. A device for representing color data values in images using color data as absolute RGB values, comprising:

representing the color data values as absolute RGB values wherein each absolute RGB value (R_0, G_0, B_0) is obtained using a predetermined transformation matrix that is based on a standard 1931 Commission Internationale de l'Eclairage D65 spectrum distribution;

labeling an image determined by the absolute RGB values as an absolute match image for corresponding *X, Y,* and *Z* values in accordance with 1931 Commission Internationale de l'Eclairage where Y has been normalized to 1.